

COBE

FIRAS TIME-ORDERED DATA

ASIR-000073/89-089A-01B

This dataset has been ingested to 4mm and 8mm tapes. The data is written in native VAX format. DD and DC numbers along with data information, numbers of files follow:

NEW ID	OLD _ID	#of FILES	Media#ori	Media#cp
ASIR-000073	89-089A-01B	4052	DD109563	DC033307
ASIR-000073	89-089A-01B	2886	DD109564	DC033308
ASIR-000073	89-089A-01B	984	DD109565	DC033309
ASIR-000073	89-089A-01B	924	DD109566	DC033310
ASIR-000073	89-089A-01B	888	DD109567	DC033311
ASIR-000073	89-089A-01B	876	DD109568	DC033312

12 FIRAS Data Products

This section of the Explanatory Supplement describes the *FIRAS* datasets not previously discussed. The datasets are addressed in the reverse order in which they are produced by the *FIRAS* data processing pipeline.

12.1 Covariance Matrices

12.1.1 Calibrated Covariance Matrices

Covariance matrices of calibrated sky data were produced by apodizing and calibrating covariance matrices produced in the coaddition of sky data (see Section 11.6). The resulting matrices thus show frequency-to-frequency covariances in the calibrated spectra, including effects induced by apodization.

Since the spectra are actually complex-valued, these matrices are broken into three pieces:

1. Covariances of the real parts of the spectra to the real parts.
2. Covariances of the real parts to the imaginary parts.
3. Covariances of the imaginary parts to the imaginary parts.

The complex-valued covariance matrix may be reconstructed from these if desired.

The overall appearance of the covariance matrices and their associated correlation matrices is highly diagonal. Frequency-to-frequency correlations drop off to less than 2% within 7 cm^{-1} from the diagonal, and their average value is less than 1% (2.5% for low short slow data) as seen in Table 12.1. Moreover the real-to-real and imaginary-to-imaginary covariance matrices are similar in shape; when the inverse of the real-to-real covariance matrix is multiplied times the imaginary-to-imaginary covariance matrix, the diagonal of their product has values near unity and the average of the absolute values of the off-diagonal elements is less than 0.053. This indicates that within a coadd, the random dispersion agrees with the noise of the signal; we can conclude that the signal is stable over a coadd and thus there is no necessity to attempt to calibrate individual interferograms.

The effects of apodization become most apparent when examining the real-to-imaginary covariances. Correlations between real and imaginary parts of adjacent frequency bins

Table 12.1: Average Absolute Off-Diagonal Correlations (percent)

	RHSS	RHSF	RHLF	RLSS	RLLF
Real-Real Abs Value	0.78	0.95	0.76	2.49	0.75
Imag-Imag Abs Value	0.77	0.93	0.74	2.50	0.75
Real-Real (Abs Value) ²	0.03	0.03	0.03	0.14	0.05
Imag-Imag (Abs Value) ²	0.03	0.03	0.03	0.14	0.05
	LHSS	LHSF	LHLF	LLSS	LLL
Real-Real Abs Value	0.76	0.95	0.76	2.46	0.76
Imag-Imag Abs Value	0.75	0.94	0.76	2.45	0.76
Real-Real (Abs Value) ²	0.03	0.04	0.03	0.14	0.05
Imag-Imag (Abs Value) ²	0.03	0.03	0.03	0.14	0.05

average approximately 30% as do those between real and imaginary parts of frequencies two bins apart for all channels except the low long fast, where the correlations between adjacent frequency bins average about 50% while those between frequencies two bins apart drop off to about 9%. This effect completely disappears if apodization is not used in calibration.

The magnitudes of the off-diagonal terms show that using the vector of sigmas from the production process in place of the covariance matrix will result in errors on the order of twice the error estimates themselves; this number is generously based on the significant number of off-diagonal rows in the correlation matrix.

The matrices also contain covariances between the following eight characterizing criteria: Xcal, Ical, Refhorn, and Skyhorn temperatures (sum/2 and difference/2 thereof), Dihedral, Collimator, and Bolometer (appropriate to channel) temperatures, and glitch rate. Covariances of each of these quantities with the real and imaginary parts of each frequency bin are included as well. This was done by adding the eight quantities above to the ends of the interferogram when the dispersion vectors which contribute to it are formed. See below for the exact layout of the matrix.

12.1.2 Covariance Matrix Datasets

The project data release includes calibrated covariance matrices and additional information for each channel and scan mode combination. Unlike other released data sets, no merged short fast/long fast covariance matrices exist since comparable combination and decimation to that used to merge sky spectra was not a possibility for the covariance matrices. As a

result, the ten released calibrated covariance matrices are for short slow, short fast, and long fast data in high channels and short slow and long fast data in low channels. Each channel and scan mode combination is contained in a single FITS file whose contents are given in Table 12.2, Table 12.3, Table 12.4, and Table 12.5.

Table 12.2: Covariance Matrix Identification Fields*

MODEL_LABEL	40-character calibration model solution label	
COV_LABEL	40-character covariance matrix identification label	
CHANSCAN	Channel/Scan mode (length and speed)	
NU_ZERO	Real Optical frequency of first data point	GHz
DELTA_NU	Real Frequency interval	GHz
NUM_FREQ	Integer number of frequency points with good data†	
NUM_IFGS	Integer number of contributing IFGs	
NUM_COADD	Integer number of contributing coadds	
DEG_FREEDOM	Integer number of degrees of freedom	
BOL_AVG	Real average bolometer temperature	K
CBIAS_AVG	Real average commanded bias	V
VOLT_AVG	Real average readout voltage	V
S0	Double precision detector responsivity	V/W
TAU	Double precision detector time constant	s
TBOL	Double precision derived bolometer temperature	K

*Each field listed is included in every record (or row).

†NUM_FREQ has been changed for high channel data sets in the July 1995 release.

When the covariance matrix is formed, the average spectrum of all calibrated spectra contributing to it is computed and recorded. For space-saving purposes, the averages of the real and imaginary parts of the calibrated spectra contributing to the covariance matrix are stored in columnar form.

For the fields BIN_TOTAL, WTD_BIN_TOTAL, EFF_WT, RDISP, IDISP, and TEMP (described in Table 12.4), each record (row) number corresponds to a classification number depending on eight different instrument conditions: whether Xcal, Ical, Refhorn, Skyhorn temperatures, glitch rate, and Galactic latitude are over/under certain limits as specified in the reference dataset FEX_CTH.TXT, whether data were taken before/after turning off the MTM in SAA passages, and whether a secondary template was subtracted in the coaddition process. Yes/no answers to each of the above questions (in order) result in

Table 12.3: Covariance Matrix Average Spectrum Fields*

AVG_RCALSPEC	Real average of real parts of calibrated spectra for this record (row)	MJy/sr
AVG_ICALSPEC	Real average of imaginary parts of calibrated spectra for this record (row)	MJy/sr

*For these two fields, record (row) 1 contains information for frequency NU_ZERO, record (row) 2 contains information for frequency NU_ZERO + DELTANU, and so forth up through NUM_FREQ. Thus records beyond the number of good frequencies will contain no data in these fields.

$2^8 = 256$ categories. Each category is stored in the record number to which it corresponds. To match a category to a record (row) number, subtract 1 from the record number, render it in binary, and read the yes/no answers corresponding to the above categories from RIGHT to LEFT respectively. For example, if record (row) number 158 contains non-zero data and the user wishes to calculate the corresponding binning criteria, first subtract 1 to get 157, which in binary notation is 10011101. Thus record (row) 158 contains information regarding data taken with a hot Xcal, normal Ical, Hot Refhorn and Skyhorn, high glitch rate, low Galactic latitude, before the MTM was turned off in SAA passages, and with secondary template subtracted. Conversely, if the user wishes to check whether any IFGs had the above mentioned characteristics, converting 10011101 to base 10 then adding 1 will indicate that the relevant information is in record (row) number 158.

The field WTD_BIN_TOTAL contains the weighted total of calibrated spectra for the binning category determined by the record (row) number. The weighted total is the sum over all coadds of $K(i) \cdot (N(i) - 1)/N(i)$, where $K(i)$ is the number of spectra from coadd i fitting the criteria for this bin and $N(i)$ is the number of spectra in coadd i .

The field EFF_WT contains the effective weight per each calibrated spectrum contributing to the bin determined by the record (row) number. The effective weight is the sum of the squares of the Euclidean norms of the dispersion vectors in that bin divided by the product of the unweighted bin total and the average of the squares of the norms of all dispersion vectors.

The fields BIN_TOTAL, WTD_BIN_TOTAL, EFF_WT, RDISP, IDISP, and TEMP will be zero in many records (rows) because no IFGs in the data set matched the criteria corresponding to that particular row number.

Since the covariance matrix itself is symmetric, only its upper half is stored in the file.

Table 12.4: Covariance Matrix Bin Total Fields

BIN_TOTAL	Integer number of calibrated spectra contributing to this record (row) number	
WTD_BIN_TOTAL	Real weighted total of calibrated spectra for this record (row) number	MJy/sr
EFF_WT	Double precision effective weight per each IFG contributing to this record (row) number	
RDISP	180-point double precision total of real part of calibrated spectra dispersions for this record (row) number	(MJy/sr) ²
IDISP	180-point double precision total of imaginary part of calibrated spectra dispersions for this record (row) number	(MJy/sr) ²
TEMP	8-point double precision totals of dispersion of characterizing quantities in this record (row), as follows: Bin 1: total dispersion of Xcal temperatures Bin 2: total dispersion of Ical temperatures Bin 3: total dispersion of sum/2 of Skyhorn and Refhorn temperatures Bin 4: total dispersion of difference/2 of Skyhorn and Refhorn temperatures Bin 5: total dispersion of Dihedral temperature Bin 6: total dispersion of Collimator temperature Bin 7: total dispersion channel-specific bolometer temperature Bin 8: total dispersion of glitches per second	K

Furthermore, the size of the matrix dictates that its upper half be stored as a single vector, resulting in a complicated layout. Details follow; in addition the user is referred to the FORTRAN-callable routine FITS_READ_COVAR which reads the file and reconstructs the covariance matrix from it. See the documentation on FITS_READ_COVAR in Section 13.2 for its exact calling sequence. (FITS_READ_COVAR extracts no other fields from the covariance matrix file.) A description of the unpacked matrix follows the field descriptions given in Table 12.5.

Table 12.5: Covariance Matrix Fields

COVAR	270-point double precision vector of part of upper triangular portion of covariance matrix (units vary; see below). The covariance matrix field consists of the upper triangular part of the symmetric covariance matrix, stored as three vectors in records (rows) 1 – 253. Each record (row) contains up to 270 values.
Real–Real	17766 values stored as one vector in records (rows) 1 – 66; upper half of symmetric submatrix $1 - 188 \times 1 - 188$
Real–Imag	33840 values stored as one vector in records (rows) 67 – 192; entirety of rectangular submatrix $189 - 368 \times 1 - 188$
Imag–Imag	16290 values stored as one vector in records (rows) 193 – 253; upper half of symmetric submatrix $189 - 368 \times 189 - 368$

The unpacked covariance matrix is of dimensions 368×368 , arranged as shown in Table 12.6.

Table 12.6: Covariance Matrix Regions

		Columns		
		1 – 180	181 – 188	189 – 368
Rows	1 – 180	Region A	Region B	Region D
	181 – 188	Region B'	Region C	Region E
	189 – 368	Region D'	Region E'	Region F

Regions B', D', and E' are transposes of regions B, D, and E respectively.

The descriptions of the various regions and their units follow:

Region A consists of the covariances between the real parts of the calibrated spectra, in

units of $(\text{MJy}/\text{sr})^2$. Thus for $1 \leq i, j \leq \text{NUM_FREQ}$, where NUM_FREQ is the number of frequency locations, entry (i, j) of the matrix will be the covariance between the real parts of the spectra at frequencies $\text{NU_ZERO} + i \cdot \text{DELTA_NU}$ and $\text{NU_ZERO} + j \cdot \text{DELTA_NU}$. Note that Region A entries will be nonzero only for these locations.

Region B consists of the covariances between the real parts of the calibrated spectra and the characterizing instrument quantities. Region B entries will be nonzero only for locations (i, j) where $1 \leq i \leq \text{NUM_FREQ}$ and $181 \leq j \leq 188$. For $1 \leq i \leq \text{NUM_FREQ}$, units for these locations are as follows:

For $181 \leq j \leq 187$, units are $\text{K} \cdot \text{MJy}/\text{sr}$. Entry (i, j) of this portion of Region B is the covariance between the real part of the calibrated spectra at frequency $\text{NU_ZERO} + i \cdot \text{DELTA_NU}$ and Xcal ($j = 181$), Ical ($j = 182$), (Skyhorn + Refhorn)/2 ($j = 183$), (Skyhorn - Refhorn)/2 ($j = 184$), Dihedral ($j = 185$), Collimator ($j = 186$), or channel-specific Bolometer dispersions ($j = 187$).

For $j = 188$, entry (i, j) is the covariance between the real part of the calibrated spectra at frequency $\text{NU_ZERO} + i \cdot \text{DELTA_NU}$ and glitches per second; its units are therefore $(\text{Glitches}/\text{s}) \cdot (\text{MJy}/\text{sr})$.

Region C consists of the covariances between the characterizing instrument quantities. Units in this region are as follows:

For $181 \leq i, j \leq 187$, units are K^2 . Entry (i, j) of this portion of Region C is the covariance between Xcal (i or $j = 181$), Ical (i or $j = 182$), (Skyhorn + Refhorn)/2 (i or $j = 183$), (Skyhorn - Refhorn)/2 (i or $j = 184$), Dihedral (i or $j = 185$), Collimator (i or $j = 186$), and channel-specific Bolometer temperatures (i or $j = 187$).

For $181 \leq i \leq 187$ and $j = 188$ or $181 \leq j \leq 187$ and $i = 188$, entry (i, j) is the covariance between the real part of the temperature and glitches per second; its units are therefore $\text{K} \cdot (\text{Glitches}/\text{s})$.

Entry $(188, 188)$ is the variance of glitches per second and its units are therefore $(\text{glitches}/\text{s})^2$.

Region D consists of the covariances between the real and imaginary parts of the calibrated spectra, in units of $(\text{MJy}/\text{sr})^2$. Thus for $1 \leq i \leq \text{NUM_FREQ}$ and $189 \leq j \leq \text{NUM_FREQ} + 188$, entry (i, j) of the matrix will be the covariance between the real part of the spectra at frequency $\text{NU_ZERO} + i \cdot \text{DELTA_NU}$ and the imaginary part at frequency $\text{NU_ZERO} + (j - 188) \cdot \text{DELTA_NU}$. Note that Region D entries will be nonzero only for these locations.

Region E consists of the covariances between the characterizing instrument quantities and the imaginary parts of the calibrated spectra. Region E entries will be nonzero only for locations (i, j) where $181 \leq i \leq 188$ and $189 \leq j \leq NUM_FREQ + 188$. For $189 \leq j \leq NUM_FREQ + 188$, units for these locations are as follows:

For $181 \leq i \leq 187$, units are K·MJy/sr. Entry (i, j) of this portion of Region B is the covariance between the imaginary part of the calibrated spectra at frequency $NU_ZERO + (j - 188) \cdot DELTA_NU$ and Xcal ($i = 181$), Ical ($i = 182$), (Skyhorn + Refhorn)/2 ($i = 183$), (Skyhorn - Refhorn)/2 ($i = 184$), Dihedral ($i = 185$), Collimator ($i = 186$), or channel-specific Bolometer dispersions ($i = 187$).

For $i = 188$, entry (i, j) is the covariance between the imaginary part of the calibrated spectra at frequency $NU_ZERO + (j - 188) \cdot DELTA_NU$ and glitches per second; its units are therefore (Glitches/s)·(MJy/sr).

Region F consists of the covariances between the imaginary parts of the calibrated spectra, in units of $(\text{MJy/sr})^2$. Thus for $189 \leq i, j \leq NUM_FREQ + 188$, entry (i, j) of the matrix will be the covariance between the imaginary parts of the spectra at frequencies $NU_ZERO + (i - 188) \cdot DELTA_NU$ and $NU_ZERO + (j - 188) \cdot DELTA_NU$. Note that Region F entries will be nonzero only for these locations.

12.2 Calibrated and Differential Spectra

The uncombined, undestriped spectra will be discussed separately in terms of sky data and calibration data.

12.2.1 Sky Data

The project data release includes the calibrated and differential sky spectra for each individual channel and scan mode prior to any destriping or combination within pixels. These spectra are the output of the calibration process described in Section 7. The number of spectra in each dataset is given in Table 12.7. The data record for these spectra is the same as that for the destriped, combined skymaps, which is given in Table 4.3.

Table 12.7: Number of Spectra in *FIRAS* Skymaps

	RHSS	RHSF	RHLF	LHSS	LHSF	LHLF
Number of pixels	5339	1725	5355	5342	1714	5321
Number of spectra	9417	2368	7935	9407	2360	7839
	RLSS	RLSF	RLLF	LLSS	LLSF	LLL
Number of pixels	5325	1720	5280	5308	1712	5234
Number of spectra	9285	2372	7212	9166	2362	7537

12.2.2 Calibration Data

The project data release includes the time-ordered calibrated and differential calibration spectra for each individual channel and scan mode. These spectra are the output of the calibration process described in Section 7, applied to the calibration coadded IFGs that are used to compute the calibration model. As described in section 11.2, these spectra are binned by temperature plateaus. The number of spectra in each dataset is given in Table 12.8. The data record for these spectra is also the same as that for the destriped, combined skymaps, which is given in Table 4.3.

Table 12.8: Number of Observations in *FIRAS* Calibration

	RHSS	RHSF	RHLF	LHSS	LHSF	LHLF
Number of spectra	484	66	161	486	66	159
Number of IFGs	24,142	2,097	6,464	24,126	2,126	6,405
	RLSS	RLSF	RLLF	LLSS	LLSF	LLL
Number of pixels	489	67	154	485	66	152
Number of spectra	23,952	2,105	6,225	23,963	2,283	5,836

12.3 Coadded Interferograms

The project data release includes the pixel-ordered coadded sky interferograms for each individual channel and scan mode. As described in Sections 11.2 and 11.3, the raw sky IFGs have been sorted by pixel number and ICAL temperature setting, normalized to unit MTM sweep and unit gain, and averaged together. The IFGs were processed in nine

mission periods of approximately one-month duration, so there is a set of skymaps for each period (though not all scan modes are present in all mission periods).

The project data release also includes the time-ordered coadded calibration interferograms for each individual channel and scan mode. As described in Sections 11.2 and 11.3, the raw calibration IFGs have been binned by temperature plateau, normalized to unit MTM sweep and unit gain, and averaged together.

The data record for the *FIRAS* coadded sky and calibration interferograms is given in Table 12.9 and Table 12.10. All coordinates are given in degrees ([0, 360] for longitudes, [-90, 90] for latitudes) for epoch J2000.0.

12.4 Index to Coadded Interferograms

The sorting processes for coaddable ensembles of sky and calibration interferograms (discussed in Section 11.2) generate so-called “Short Science” records. These are highly reduced (64 byte) index records – one for each interferogram – that summarize the instrument state (*e.g.*, detector and calibrator temperatures), pointing (Galactic longitude and latitude, pixel number, moon offset angle, etc.), and mirror scan mode. They contain no science data, but point back to each raw interferogram through the time tag in the first field of each record. These index records will be discussed for both the sky and calibration data.

12.4.1 Sky Coadd Index

For sky data, the order in which the Short Science records occur reflects the primary and secondary sorting keys. The primary key is pixel number; secondary keys are the mirror scan length, mirror scan speed, and internal calibrator temperature. Detector (RH, RL, etc.) is not a sort key: data from the four detectors live in different files and are sorted and processed independently.

A given Short Science file will generally contain a large number of records corresponding to many coadd groups for a given detector channel. In order to demarcate the groups each Short Science record contains a “transition flag”, a single byte that takes on a nonzero value to indicate the start of a new group. Not all groups are considered to be “coaddable”, however: ensembles smaller than 5 interferograms are considered to be too small to be statistically reliable. Thus, a transition flag value of 1 indicates the start of a

Table 12.9: Field Names of *FIRAS* Coadded Interferogram Datasets

COADDED_IFG	Coadded interferogram (512 points)	counts
REAL_VARIANCE	Variance of real part of coadded spectrum (180 points)	(MJy/sr) ²
IMAG_VARIANCE	Variance of imaginary part of coadded spectrum (180 points)	(MJy/sr) ²
REAL_IMAG_VARIANCE	Covariance between real and imaginary parts of coadded spectrum (180 points)	(MJy/sr) ²
GLITCH_RATE	Glitchrate for coadded IFG	glitches/s
NUM_IFGS	Number of IFGs in coadded spectrum	
NUM_TEMPLATES	Number of templates subtracted from coadded IFG	
TIME	Average IFG timetag, in seconds since 0 UTC, 1 January 1981	
Data and Scan Mode Identification		
DATATYPE	Sky or calibration data indicator	8, 9*
CHANSCAN	Channel/Scan mode (length and speed)	
PEAK_POS	Interferogram Peak Position	
BOLOM_BIAS	Commanded bolometer bias	V
BOLOM_VOLTAGE	Bolometer readout voltage	V
NU_ZERO	Frequency of initial data point (variances)	GHz
DELTA_NU	Frequency interval (variances)	GHz
NUM_FREQ	Number of frequency points in variance with good data†	

*The DATATYPE field is used for both spectral and coadded interferogram data. The DATATYPE, CALIBRATED, and DESTRIPED fields in previous data releases have been merged in the July 1995 release. The nine data types are

1. Merged channel and scan mode destriped calibrated sky spectra;
2. Merged scan mode destriped calibrated sky spectra;
3. Single scan mode destriped calibrated sky spectra;
4. Single scan mode undestriped calibrated sky spectra;
5. Single scan mode undestriped differential sky spectra;
6. Single scan mode undestriped calibrated calibration spectra;
7. Single scan mode undestriped differential calibration spectra;
8. Coadded sky interferograms;
9. Coadded time-ordered calibration interferograms.

†NUM_FREQ has been changed for high channel data sets in the July 1995 release.

Table 12.10: Field Names of *FIRAS* Coadded Interferogram Datasets, Continued

Instrument Temperatures		
XCAL_TEMP	External calibrator temperature	K
ICAL_TEMP	Internal calibrator temperature	K
SKYHORN_TEMP	Sky horn temperature	K
REFHORN_TEMP	Reference horn temperature	K
DIHEDRAL_TEMP	Dihedral mirror temperature	K
MIRROR_TEMP	Collimator mirror temperature	K
BATH_TEMP	Bolometer bath temperature	K
Instrument Attitude Information*		
PIXEL	<i>FIRAS</i> pixel number	[0, 6143]
ECLON	Ecliptic longitude	degrees [0, 360]
ECLAT	Ecliptic latitude	degrees [-90, 90]
GALON	Galactic longitude	degrees [0, 360]
GALAT	Galactic latitude	degrees [-90, 90]
RA	Right ascension	degrees [0, 360]
DEC	Declination	degrees [-90, 90]
GALATEXC	Galactic latitude above which data are excluded for this release	90°

*Certain attitude fields which contained no meaningful data have been eliminated from the July 1995 Supplemental Dataset Release.

group containing four or fewer records, while a value of 2 occurs in the first record of a group of 5 or more.

The project datasets include Short Science records for the *FIRAS* sky interferograms (FSS_SSSKY) in all four channels. These records are being released in their native VAX binary file formats. The record structures for these binary files are given in Appendix H. The filename extensions of these files (*e.g.*, ED_8932800_8934301) incorporate the timetags of the earliest and latest data records contained in the files, using the format YY-DDD-HH.

12.4.2 Calibration Coadd Index

The file structure and fields for the calibration index records are identical to the sky index records, with one exception: the transition flag takes on only two possible values, 0 and -1 (all bits set to 1), with the latter value marking the last record in a coadd group rather than the first. (Unlike in the sorting of sky data, no groups smaller than 5 interferograms are ever created, so no "uncoaddable groups" exist. Hence no third transition flag value is needed.) Spacecraft pointing information is also included in the record for uniformity with the sky index records, but no celestial emission is detectable during calibration periods, even at very small moon aspect angles.

The other way in which calibration index records differ from the sky Short Science records is that the primary sorting key is time rather than pixel number, as discussed in Section 11.2 earlier. The secondary sorting keys, besides the mirror scan mode, are the four controllable temperatures (external and internal calibrators, and sky and reference horns) as well as commanded bolometer bias.

The project datasets include Short Science records for the *FIRAS* calibration interferograms (FEC_SSCAL) in all four channels. These records are being released in their native VAX binary file formats. The record structures for these binary files is given in Appendix H. The filename extensions of these files (*e.g.*, ED_8935312_8935323) incorporate the timetags of the earliest and latest data records contained in the files, using the format YY-DDD-HH.

12.5 Time-Ordered Interferograms

The first science data set produced by the *FIRAS* Pipeline, FDQ_SDF, contains the time-ordered interferograms (IFGs). The sky IFGs were taken continuously throughout the

mission for the two redundant low frequency and high frequency detectors with intermissions of planned calibrations. The science data are archived from the telemetry stream into four data sets, one for each *FIRAS* detector. The on-board microprocessors collect each IFG and buffer it for transmission along with other relevant information. Ten bytes of each telemetry minor frame buffer are reserved for each of the *FIRAS* channels. A sync code in the first reserved word for each channel signals the start of an IFG transmission, which requires 114 consecutive minor frames in the telemetry stream.

Instrument state information, the IFG start of collection time, data quality flags, and attitude information are added to the basic science records during subsequent pipeline processing. There is no separation at the raw time-ordered IFG stage for detector data taken at different MTM scan modes. The project data release includes time-ordered interferogram records in all four channels (RH, RL, LH, LL). These records are being released in their native VAX binary file format. The record structure for these binary files is given in Appendix H. The filename extensions of these files (*e.g.*, ED_893280000) incorporate the timetag of the earliest data record contained in the files, using the format YY-DDD-HH-MM.

12.6 Engineering Data

The engineering data, FDQ_ENG, consist of time-ordered records of 1024 bytes each storing the engineering status of the *FIRAS* instrument at a particular time. The status includes the microprocessor status words, temperatures, voltages, and currents. The records are stored in files each containing one day of *FIRAS* data.

These data are derived from the housekeeping data, which transmit the *FIRAS* instrument status in microprocessor counts in every two major frames. The science records are grouped according to the proximity of the midpoints of the interferogram collection times. Each group may have from one to four science records from the four science channels. The two housekeeping major frames whose times bracket the average time of the science record group are found. The data in the housekeeping records are converted from microprocessor counts to physical units, and then interpolated to determine values for each engineering quantity at the average science record group time. This time is assigned to the new engineering record, and is also put into each of the science records in the group. The science record times are put into the engineering record, so that the science and engineering data are doubly cross-indexed.

The project data release includes engineering records in all four channels. These records are being released in their native VAX binary file format. The record structure for these

binary files is given in Appendix H. The filename extensions of these files (*e.g.*, ED_893280000) incorporates the timetag of the earliest data record contained in the files, using the format YY-DDD-HH-MM.

12.7 Housekeeping and Ancillary Data

The housekeeping data, NFS_HKP, consist of time-ordered records of 576 bytes each storing the engineering status of the *FIRAS* instrument. These data are in unconverted microprocessor counts. They are stripped from the *COBE* telemetry stream in pairs of major frames, and are not synchronized with the science data. The time of the first major frame is in the header section of the record and the time of the second major frame appears at the end of the record. The *FIRAS* pipeline facility FDQ converts the engineering data to physical units and associates them with the science data.

The housekeeping data include the microprocessor and other status words, the GRT and other temperatures, the Internal Power Distribution Unit voltages and currents, and other miscellaneous engineering quantities.

The raw ancillary data, NFS_ANC, consist of time-ordered records of 392 bytes, each containing the pair of telemetry major frames corresponding to the raw housekeeping data. For each major frame, the record contains 128 minor frames of status bits packed into one byte per minor frame. The status bits are the MTM scan direction bit, the external calibrator status bit, the MTM scan length, the MTM scan speed, and four microprocessor data ready bits.

The project data release includes housekeeping and ancillary records in all four channels. These records are being released in their native VAX binary file format. The record structure for these binary files is given in Appendix H. The filename extensions of these files (*e.g.*, ED_893272157) incorporate the timetag of the earliest data record contained in the files, using the format YY-DDD-HH-MM.

12.8 Engineering Mode Timing Data

The engineering mode timing data, NFS_EMF, consist of time-ordered records of Mirror Transport Mechanism timing information. These data provides a direct measurement of the time between MTM samples. For each channel, the flight microprocessors output the elapsed time between samples for one MTM sweep into a 512-point, 8-bit array. The time

elapsed between sample pulses is computed in microseconds as follows:

$$time = 45 + (10.0 \cdot counts)$$

where *counts* is the timing data. During the mission, engineering mode timing data were taken early in the mission during the post-launch spacecraft checkout and late in the mission during post-cryogen depletion engineering tests. Analyses of these data yielded the MTM sampling rates discussed in Section 2 and used in the reference dataset FEX_MTMSAMPRATE.TXT discussed in the following section. Fourier analysis of the data yielded the frequencies of the coherent vibrations discussed in Sections 7 and 8.2.1.

The project data release includes engineering mode timing data in all four channels (RH, RL, LH, LL). These records are being released in their native VAX binary file format. The record structure for these binary files is given in Appendix H. The filename extensions of these files (*e.g.*, ED_893252233) incorporate the timetag of the earliest data record contained in the files, using the format YY-DDD-HH-MM.

12.9 Reference Datasets

The *FIRAS* data processing software has been designed so that the values of many parameters that affect how the programs operate are read from reference datasets. This design has allowed the modification of the values contained in the reference datasets without modifying data processing programs. A number of the parameters which comprise these reference datasets are contained in project datasets previously discussed. Several additional reference datasets may be of use in understanding how the *FIRAS* data have been processed. These datasets, which are in both ASCII and VAX binary file formats, are discussed below and are also part of the *FIRAS* project dataset release.

12.9.1 ASCII Format Reference Datasets

Glitchrate Correction Parameters. Glitches add substantially to the noise in the data. Consequently, high glitchrate data are deweighted with respect to low glitchrate data. As described in Section 8.2.3, a linear least squares fit to the average variance and glitchrate of each calibrated sky spectrum generated a set of corrections for the numbers of IFGS in the *FIRAS* spectra. These corrections are shown in Table 8.2 and are listed in the reference dataset FEX_GLTCHCOR.TXT given in Appendix I.

Vibration Correction Frequency Offset Indices. The calibration of the *FIRAS* spectra includes corrections for coherent vibrations at 57.57 and 8.55 Hz (see Sections 7.2.2 and 8.2.1). These corrections are applied at channel- and scan mode-specific offsets in frequency from the vibrations (see Section 7.6). These offset indices are listed in the reference dataset FEX_VIBCORR.TXT given in Appendix I.

Actual Values of Commanded Instrument Gains. The coaddition program normalized the interferograms by the preamplifier gain before averaging them together, as discussed in Section 11.3. The values of the commanded gains for each channel are listed in the reference dataset FEX_CMDGAIN.TXT given in Appendix I.

Mirror Transport Mechanism Sampling Rate. As discussed in Section 2, the Mirror Transport Mechanism samples the data at a fixed clockrate. This clockrate (681.43 Hz for on-orbit data, 673.29 Hz for preflight ground data) is listed in the reference dataset FEX_MTMSAMPRATE.TXT given in Appendix I.

Mirror Transport Mechanism Scan Times. As discussed in Section 2, the Mirror Transport Mechanism takes an average of about 40 seconds to collect the data averaged by the instrument microprocessors into single interferograms. The time required for a single sweep of the MTM in each scan mode is listed in the reference dataset FEX_MTMSWEEP.TXT given in Appendix I.

Coaddition Consistency Check Thresholds. As discussed in Section 11.3, the coaddition program verified that the members of the ensembles of coaddable interferograms were in a consistent instrument state and had a consistent shape. The threshold values and tolerances used for these consistency checks are listed in the reference dataset FEX_CTH.TXT given in Appendix I.

The following instrument state parameters were evaluated for the instrument state consistency check:

1. channel, scan mode, adds per group, number of MTM sweeps
2. attitude
3. bolometer voltage
4. GRT temperatures, spatial gradients, and temporal gradients

For an ensemble to be averaged, a minimum of 5 IFGs was required to pass the instrument state consistency check.

The following quantities determined whether or not secondary template formation and subtraction occurred:

1. amplitude and signal-to-noise ratio of primary template
2. amplitude and signal-to-noise ratio of secondary template.

Deglitching occurred after primary and secondary template formation and subtraction took place.

The following quantities were evaluated after deglitching for the shape consistency check:

1. interferogram noise
2. maximum number of outlier points

For an ensemble to be averaged, a minimum of 2 IFGs was required to pass the shape consistency check.

The following instrument state parameters were binned as part of the covariance analysis:

1. Xcal, Ical, skyhorn, reference horn, and bolometer temperatures
2. glitchrate
3. Galactic latitude
4. time in mission (pre- or post-MTM shutoff in SAA)

These quantities comprise the final elements of the covariance matrix vectors.

Minimum Number of IFGs to Average. As discussed in Section 11.3, the coaddition program only averages ensembles of interferograms containing at least five members. The minimum number of IFGs required for coaddition is listed in the reference dataset FEX_MINCOADD.TXT given in Appendix I.

GRT Weights for Coadded IFGs. As discussed in Section 7.4, the *FIRAS* has 24 GRTs and 8 calibration resistors mounted throughout its structure to measure the temperatures of various components of the instrument. Readings from the 24 GRTs are combined to yield ten temperatures that are used in calibrating the data. The relative weights used to combine the GRT readings for the calibration of coadded interferograms are listed in the reference dataset FEX_GRTCOAWT.TXT given in Appendix I.

GRTs that are broken, are non-existent, or give spurious readings have their weights set to zero. GRTs that should be combined unequally are weighted accordingly. The calibration resistors also have their weights set to zero.

The Xcal B and Collimator B GRTs are broken or non-existent, so their weights are set to zero. The Skyhorn B GRT shows temperature spikes due to charged particle hits, so its weight is set to zero. The calibration program computes a lower χ^2 when the Xcal temperature is combined from the cone GRTs alone, so the Xcal A (tip) GRT has a weight of zero. The calibration program also computed a lower χ^2 when the structure temperature is read from the collimator mirror alone, so the Mirror A and Mirror B GRTs have their weights set to zero. Finally, the calibration program computes a lower χ^2 when the Ical temperature is combined as 90% cone and 10% tip, so the Ical A GRT has a weight of 0.1 and the Ical B GRT has a weight of 0.9. All of the other GRTs are combined with equal weights.

GRT Weights for Raw IFGs. As discussed in Sections 11.2 and 11.3, temperatures of various components of the *FIRAS* are used to sort raw IFGs into coaddable ensembles and to check the consistency of the members of these ensembles. The relative weights used to combine the GRT readings for the sorting and consistency checking of the raw IFGs are listed in the reference dataset FEX_GRTRAWWT.TXT given in Appendix I.

In general, the weights are set to one since instrument “sides” are not combined. The Xcal B and Collimator B GRTs are broken or non-existent, so their weights are set to zero. The Xcal A and S5 GRTs are set to 0.5 for the Xcal combination, and the A side Mirror and Collimator GRTs are equally weighted for the A side structure measurement. The calibration resistors also have their weights set to zero.

GRT Low/High Current Transition Temperatures. The *FIRAS* GRTs have two temperature-dependent operating regimes. For the low-temperature regime, “low current” readings of the GRTs yield correct resistances and temperatures, while for the high-temperature regime, “high current” readings yield correct values. There are temperature transition regions for each GRT between these two regimes. The transition

region midpoint and half-width for each GRT are listed in the reference dataset FEX_GRTRRANS.TXT given in Appendix I.

12.9.2 VAX Binary Format Reference Datasets

Digital Transient Response Functions. The onboard digital filters add a transient signal to the samples at the beginning of each interferogram. As discussed in Section 11.3, the coaddition program corrects for this signal by fitting a digital transient response function to the first 128 points of the IFG and subtracting that fitted response from the IFG. The functional form of the digital transient response function is the Z-transform of the lowpass digital filter contained within the electronics transfer function (see Sections 7.2.1 and 7.5.2).

The *FIRAS* reference dataset FEX_DTRF.DAT is a VAX binary format file which contains eight digital transient response function records, each of which is a floating-point array 128 samples long. These functions are dependent on the frequency (high or low) and the scan mode (short slow, short fast, long slow, or long fast) of the data. The Record Definition Language file for this dataset is given in Appendix H.

Glitch Profiles. As discussed in Sections 8.2.3 and 11.3, charged particles incident on the *FIRAS* bolometers give rise to “glitches” in the interferograms. The charged particles deposit a spike of energy in the detectors, giving rise to a delta function response on the part of the detectors. Consequently, the glitch spectrum is the product of the instrument electronics transfer function and the detector time constant:

$$GS(\omega) = \frac{Z(\omega)}{1 + i\omega\tau}$$

where ω is the audio frequency of the instrument, $Z(\omega)$ is the electronics transfer function and τ is the detector time constant discussed in Section 7.5.2. Recall from Section 7.5.1 that the audio frequency ω in rad/s is related to the optical frequency ν in cm⁻¹ by the MTM scan speed v in cm/s:

$$\omega = v\nu$$

The glitch profile in the time domain is the inverse Fourier transform of the glitch spectrum:

$$GP(x) = \Omega^{-1} \int_{-\infty}^{+\infty} d\nu e^{-2\pi i\nu x} \frac{Z(v\nu)}{1 + iv\nu\tau}$$

where Ω is the normalization of the transform. As discussed in Section 11.3, the coaddition program uses the glitch profiles in the time domain to “deglitch” the interferograms.

The *FIRAS* reference dataset FEX_GLTCHPRO.DAT is a VAX binary format file which contains 312 glitch profile records in the time domain, each of which is a floating-point array 512 samples long. The first 510 points of the record store the actual glitch profile; point 511 is index of glitch peak position; and point 512 is offset from the glitch peak position to the "actual" peak position obtained by parabolic interpolation. The glitch profiles have been normalized so that they have zero integral and peak values of unity. The glitch profiles are dependent on the MTM scan speed, on the channel, and on the position of the glitch within the raw data stream (the data stream prior to on-orbit averaging by the instrument microprocessors, as discussed in Section 2). Consequently there are 26 profiles for each channel/scan speed combination. The Record Definition Language file for this dataset is given in Appendix H.

Baseline Basis Vectors. Internal defocussing of the instrument gives rise to non-zero baselines in the interferograms at the ends of the Mirror Transport Mechanism sweeps. As discussed in Section 11.3, the coaddition program corrects for this baseline by fitting a fourth-order polynomial baseline to the coadded IFG and subtracting that fitted baseline from the IFG. The basis vectors for the polynomial baseline are the first five Legendre polynomials on a 512-point scale running between -255/256 and 1.0. The Legendre polynomials that form the basis vectors are:

$$P_0(x) = 1$$

$$P_1(x) = x$$

$$P_2(x) = \frac{3}{2}x^2 - \frac{1}{2}$$

$$P_3(x) = \frac{5}{2}x^3 - \frac{3}{2}x$$

$$P_4(x) = \frac{35}{8}x^4 - \frac{15}{4}x^2 - \frac{3}{8}$$

The *FIRAS* reference dataset FEX_BASIS.DAT is a VAX binary format file which contains the five basis vectors, each of which is a double-precision array 512 samples long. The Record Definition Language file for this dataset is given in Appendix H.

5/22/96

Tape FPDS1

FIRAS_CALIBRATED_CAL_SPECTRA_LHLF.FITS;1	272 FITS Records,	177 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LHSF.FITS;1	114 FITS Records,	70 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LHSS.FITS;1	768 FITS Records,	512 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LLFL.FITS;1	262 FITS Records,	170 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LLFS.FITS;1	113 FITS Records,	69 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LLLF.FITS;1	262 FITS Records,	170 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_LLSS.FITS;1	768 FITS Records,	512 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RHLF.FITS;1	272 FITS Records,	177 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RHSF.FITS;1	115 FITS Records,	71 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RHSS.FITS;1	765 FITS Records,	510 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RLFL.FITS;1	268 FITS Records,	174 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RLFS.FITS;1	115 FITS Records,	71 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RLLF.FITS;1	268 FITS Records,	174 Spectra
FIRAS_CALIBRATED_CAL_SPECTRA_RLSS.FITS;1	772 FITS Records,	515 Spectra
FIRAS_COADDED_CAL_INTERFEROGRAMS_LHLF.FITS;1	396 FITS Records,	177 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LHSF.FITS;1	163 FITS Records,	70 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LHSS.FITS;1	1129 FITS Records,	512 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LLFL.FITS;1	381 FITS Records,	170 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LLFS.FITS;1	160 FITS Records,	69 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LLLF.FITS;1	381 FITS Records,	170 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_LLSS.FITS;1	1129 FITS Records,	512 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RHLF.FITS;1	396 FITS Records,	177 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RHSF.FITS;1	165 FITS Records,	71 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RHSS.FITS;1	1124 FITS Records,	510 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RLFL.FITS;1	390 FITS Records,	174 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RLFS.FITS;1	165 FITS Records,	71 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RLLF.FITS;1	390 FITS Records,	174 Coadds
FIRAS_COADDED_CAL_INTERFEROGRAMS_RLSS.FITS;1	1135 FITS Records,	515 Coadds
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LHLF.FITS;1	272 FITS Records,	177 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LHSF.FITS;1	114 FITS Records,	70 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LHSS.FITS;1	768 FITS Records,	512 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LLFL.FITS;1	262 FITS Records,	170 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LLFS.FITS;1	113 FITS Records,	69 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LLLF.FITS;1	262 FITS Records,	170 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_LLSS.FITS;1	768 FITS Records,	512 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RHLF.FITS;1	272 FITS Records,	177 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RHSF.FITS;1	115 FITS Records,	71 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RHSS.FITS;1	765 FITS Records,	510 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RLFL.FITS;1	268 FITS Records,	174 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RLFS.FITS;1	115 FITS Records,	71 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RLLF.FITS;1	268 FITS Records,	174 Spectra
FIRAS_DIFFERENTIAL_CAL_SPECTRA_RLSS.FITS;1	772 FITS Records,	515 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RHLF.FITS;1	40881 FITS Records,	27637 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RHSF.FITS;1	7493 FITS Records,	5060 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RHSS.FITS;1	50916 FITS Records,	34423 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RLFL.FITS;1	40332 FITS Records,	27266 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RLFS.FITS;1	7576 FITS Records,	5116 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RLLF.FITS;1	40332 FITS Records,	27266 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_RLSS.FITS;1	50951 FITS Records,	34447 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LHLF.FITS;1	40876 FITS Records,	27634 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LHSF.FITS;1	7510 FITS Records,	5071 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LHSS.FITS;1	51405 FITS Records,	34754 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LLFL.FITS;1	39745 FITS Records,	26869 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LLFS.FITS;1	7442 FITS Records,	5025 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LLLF.FITS;1	39745 FITS Records,	26869 Spectra
FIRAS_CALIBRATED_SKY_SPECTRA_LLSS.FITS;1	50860 FITS Records,	34385 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RHLF.FITS;1	40881 FITS Records,	27637 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RHSF.FITS;1	7493 FITS Records,	5060 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RHSS.FITS;1	50916 FITS Records,	34423 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LHLF.FITS;1	40876 FITS Records,	27634 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LHSF.FITS;1	7510 FITS Records,	5071 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LHSS.FITS;1	51405 FITS Records,	34754 Spectra

Total of 62 Files, 692,917 FITS Records, 3,897,659 Blocks.

Tape FPDS2

FIRAS_DIFFERENTIAL_SKY_SPECTRA_RLFL.FITS;1	40332 FITS Records, 27266 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RLFS.FITS;1	7576 FITS Records, 5116 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RLLF.FITS;1	40332 FITS Records, 27266 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_RLSS.FITS;1	50951 FITS Records, 34447 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LLFL.FITS;1	39745 FITS Records, 26869 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LLFS.FITS;1	7442 FITS Records, 5025 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LLLF.FITS;1	39745 FITS Records, 26869 Spectra
FIRAS_DIFFERENTIAL_SKY_SPECTRA_LLSS.FITS;1	50860 FITS Records, 34385 Spectra
FIRAS_COADDED_SKY_INTERFEROGRAMS_RHLF.FITS;1	60417 FITS Records, 27637 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RHSF.FITS;1	11069 FITS Records, 5060 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RHSS.FITS;1	75250 FITS Records, 34423 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RLFL.FITS;1	59607 FITS Records, 27266 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RLFS.FITS;1	11192 FITS Records, 5116 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RLLF.FITS;1	59607 FITS Records, 27266 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_RLSS.FITS;1	75303 FITS Records, 34447 Coadds

Total of 15 Files, 629,428 FITS Record, 3,540,533 Blocks.

Tape FPDS3

FIRAS_COADDED_SKY_INTERFEROGRAMS_LHLF.FITS;1	60411 FITS Records, 27634 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LHSF.FITS;1	11094 FITS Records, 5071 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LHSS.FITS;1	75974 FITS Records, 34754 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LLFL.FITS;1	58739 FITS Records, 26869 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LLFS.FITS;1	10993 FITS Records, 5025 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LLLF.FITS;1	58739 FITS Records, 26869 Coadds
FIRAS_COADDED_SKY_INTERFEROGRAMS_LLSS.FITS;1	75167 FITS Records, 34385 Coadds

Total of 7 Files, 351,117 FITS Records, 1,975,034 Blocks.

6/4/96

Tape FPDS4

FEC_SSCAL_LH.ED_8935312_8935323;1
FEC_SSCAL_LH.ED_8935323_8935402;1
FEC_SSCAL_LH.ED_8935402_8935414;1
FEC_SSCAL_LH.ED_8935414_8935414;1
FEC_SSCAL_LH.ED_8935415_8935415;1
FEC_SSCAL_LH.ED_8935415_8935418;1
FEC_SSCAL_LH.ED_8935419_8935422;1
FEC_SSCAL_LH.ED_8935422_8935503;1
FEC_SSCAL_LH.ED_8935504_8935505;1
FEC_SSCAL_LH.ED_8935505_8935511;1
FEC_SSCAL_LH.ED_8935511_8935513;1
FEC_SSCAL_LH.ED_8935513_8935515;1
FEC_SSCAL_LH.ED_8935515_8935515;1
FEC_SSCAL_LH.ED_9001815_9001922;1
FEC_SSCAL_LH.ED_9001922_9001923;1
FEC_SSCAL_LH.ED_9002000_9002002;1
FEC_SSCAL_LH.ED_9004715_9004719;1
FEC_SSCAL_LH.ED_9004720_9004720;2
FEC_SSCAL_LH.ED_9004720_9004721;1
FEC_SSCAL_LH.ED_9004721_9004721;1
FEC_SSCAL_LH.ED_9004722_9004722;1
FEC_SSCAL_LH.ED_9004723_9004723;1
FEC_SSCAL_LH.ED_9004800_9004800;1
FEC_SSCAL_LH.ED_9004800_9004801;1
FEC_SSCAL_LH.ED_9004801_9004802;1
FEC_SSCAL_LH.ED_9004802_9004804;1
FEC_SSCAL_LH.ED_9004805_9004805;1
FEC_SSCAL_LH.ED_9004805_9004814;1
FEC_SSCAL_LH.ED_9004814_9004814;2
FEC_SSCAL_LH.ED_9004815_9004815;1
FEC_SSCAL_LH.ED_9004816_9004816;1
FEC_SSCAL_LH.ED_9004816_9004817;1
FEC_SSCAL_LH.ED_9004817_9004817;1
FEC_SSCAL_LH.ED_9004817_9004818;1
FEC_SSCAL_LH.ED_9004818_9004822;1
FEC_SSCAL_LH.ED_9004822_9004823;1
FEC_SSCAL_LH.ED_9004900_9004902;1
FEC_SSCAL_LH.ED_9007713_9007714;1
FEC_SSCAL_LH.ED_9007715_9007715;1
FEC_SSCAL_LH.ED_9007716_9007717;1
FEC_SSCAL_LH.ED_9007717_9007717;1
FEC_SSCAL_LH.ED_9007718_9007718;1
FEC_SSCAL_LH.ED_9007719_9007719;1
FEC_SSCAL_LH.ED_9007720_9007721;1
FEC_SSCAL_LH.ED_9007722_9007722;1
FEC_SSCAL_LH.ED_9007722_9007723;1
FEC_SSCAL_LH.ED_9007723_9007801;1
FEC_SSCAL_LH.ED_9007801_9007820;1
FEC_SSCAL_LH.ED_9007820_9007821;1
FEC_SSCAL_LH.ED_9007821_9007821;1
FEC_SSCAL_LH.ED_9007821_9007823;1
FEC_SSCAL_LH.ED_9007823_9007900;1
FEC_SSCAL_LH.ED_9007900_9007901;1
FEC_SSCAL_LH.ED_9007901_9007903;1
FEC_SSCAL_LH.ED_9007904_9007908;1
FEC_SSCAL_LH.ED_9007908_9007909;1
FEC_SSCAL_LH.ED_9007909_9007915;1
FEC_SSCAL_LH.ED_9007915_9007916;1

FEC_SSCAL_LH.ED_9007916_9007916;1
FEC_SSCAL_LH.ED_9010719_9010720;1
FEC_SSCAL_LH.ED_9010720_9010720;1
FF_SSCAL_LH.ED_9010721_9010722;1
FEC_SSCAL_LH.ED_9010723_9010800;1
FEC_SSCAL_LH.ED_9010801_9010801;1
FEC_SSCAL_LH.ED_9010801_9010802;1
FEC_SSCAL_LH.ED_9010802_9010802;1
FEC_SSCAL_LH.ED_9010803_9010803;1
FEC_SSCAL_LH.ED_9010804_9010804;1
FEC_SSCAL_LH.ED_9010806_9010902;1
FEC_SSCAL_LH.ED_9010902_9010903;1
FEC_SSCAL_LH.ED_9010903_9010916;1
FEC_SSCAL_LH.ED_9010916_9010922;1
FEC_SSCAL_LH.ED_9010922_9011000;1
FEC_SSCAL_LH.ED_9011000_9011000;1
FEC_SSCAL_LH.ED_9011001_9011006;1
FEC_SSCAL_LH.ED_9011007_9011009;1
FEC_SSCAL_LH.ED_9011010_9011013;1
FEC_SSCAL_LH.ED_9011014_9011015;1
FEC_SSCAL_LH.ED_9011015_9011017;1
FEC_SSCAL_LH.ED_9011017_9011017;1
FEC_SSCAL_LH.ED_9011018_9011018;1
FEC_SSCAL_LH.ED_9013521_9013521;1
FEC_SSCAL_LH.ED_9013522_9013614;1
FEC_SSCAL_LH.ED_9013615_9013622;1
FEC_SSCAL_LH.ED_9013700_9013700;1
FEC_SSCAL_LH.ED_9013700_9013704;1
FEC_SSCAL_LH.ED_9013705_9013705;1
FF_SSCAL_LH.ED_9013705_9013707;1
FL_SSCAL_LH.ED_9013707_9013709;1
FEC_SSCAL_LH.ED_9013709_9013710;1
FEC_SSCAL_LH.ED_9013711_9013716;1
FEC_SSCAL_LH.ED_9013717_9013717;1
FEC_SSCAL_LH.ED_9013718_9013719;1
FEC_SSCAL_LH.ED_9013719_9013719;1
FEC_SSCAL_LH.ED_9013722_9013800;1
FEC_SSCAL_LH.ED_9013801_9013802;1
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Total of 1342 Files, 1,321,532 Blocks.